Small Business Innovation Research/Small Business Tech Transfer

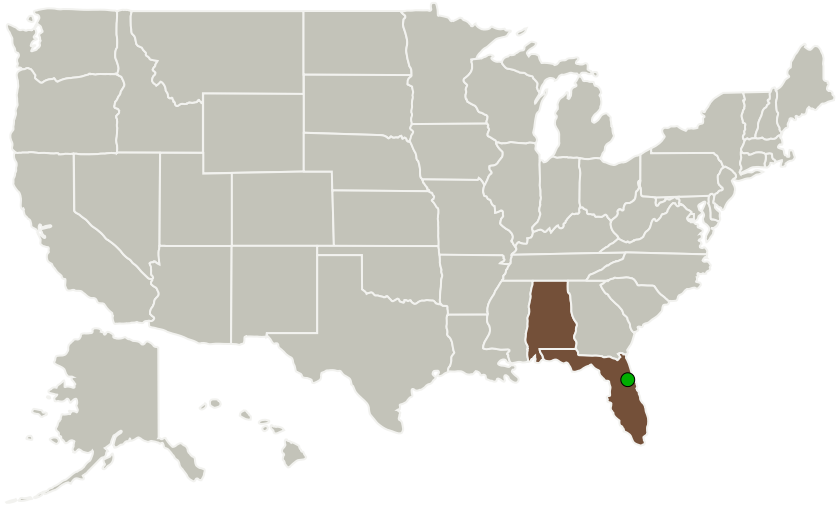
High-Fidelity Gas and Granular Flow Physics Models for Rocket Exhaust Interaction with Lunar Soil, Phase II

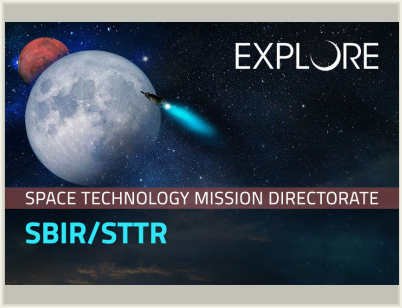
Completed Technology Project (2010 - 2013)

Project Introduction

Current modeling of Lunar and Martian soil erosion and debris transport caused by rocket plume impingement lacks essential physics from the peculiar granular characteristics of highly irregular regolith particles. Current granular mechanics models are based on mono-disperse spherical particles empiricism unsuitable for capturing the poly-disperse irregularly shaped grain mechanics. CFDRC and the University of Florida successfully demonstrated a novel approach in Phase I to develop granular mechanics constitutive models through innovative Discrete Element Methods emulating non-spherical, jagged particles constructed as clusters of linked/overlapping spheres. This first principle modeling captures the fundamental relationship between particle shape and particle-phase stress, cohesion, and particle flow kinetics. In Phase II, detailed regolith granular flow constituent models will be derived with these methods. An Eulerian granular phase model with the resulting constitutive models will be implemented in the Unified Flow Solver (UFS) simulation framework developed by CFDRC and UF for lunar debris transport and applied in Eulerian multi-phase gas-regolith interaction simulations. Surface stresses from turbulent jet plume scouring and regolith roughness that amplify erosion mechanisms will be captured using a Reynolds Stress Turbulence model. The integrated UFS simulation tool will be validated against erosion and cratering experiments with sand, lunar/Mars simulants, and reduced gravity effects. The technology will be applied for Moon/Mars landing crater formation and debris transport predictions. This high-fidelity simulation capability will be essential for predicting regolith dust and debris transport and for developing mitigation measures.

Primary U.S. Work Locations and Key Partners





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Organizations Performing Work	Role	Type	Location
CFD Research Corporation	Lead Organization	Industry	Huntsville, Alabama
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida
University of Florida	Supporting Organization	Academia	Gainesville, Florida

Primary U.S. Work Locations	
Alabama	Florida

Project Transitions

September 2010: Project Start

June 2013: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139079)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CFD Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

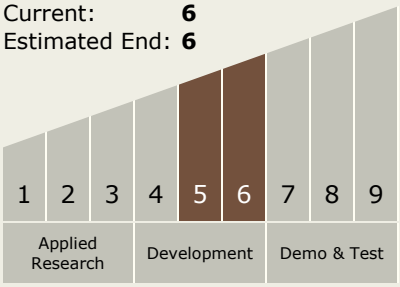
Carlos Torrez

Principal Investigator:

Peter Liever

Technology Maturity (TRL)

Start: **5**
Current: **6**
Estimated End: **6**



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Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.4 Vehicle Systems
    - TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System